NATIONAL BUREAU OF STANDARDS REPORT

10 109

EVALUATION OF AIR FILTER MEDIA

Supplement to NBS Report 10025

Report to

Bureau of Research and Engineering
Post Office Department
Washington, D. C. 20260

NBS

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

NATIONAL BUREAU OF STANDARDS

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[1] Headquarters and Laboratories at Gaithersburg, Maryland, unless otherwise noted; mailing address Washington, D.C. 20234.
[2] Located at Boulder, Colorado 80302.
[3] Located at 5285 Port Royal Road, Springfield, Virginia 22151.

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Charles M. Hunt

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Summary

1. Polyurethane foam usage was analyzed after 331 days in service. The average length of service for the initially installed filters was 297 days compared with 173 days for fiber glass. This would correspond to a cost saving of more than 20 percent. However in seven air handling units, subsequent sets of filters did not last as long as the original polyurethane filters. Due to variability of usage data for both polyurethane and fiber glass it is difficult to make a firm universally applicable cost estimate.
2. Laboratory tests indicated that dirty polyurethane media which had been washed may have had a slightly higher resistance to air flow than new media, but more information on roll-to-roll variation would be necessary to establish whether this small difference between new and washed media is significant.
3. Comparison of 20 ft. rolls of washed and unwashed polyurethane foam at the Philadelphia Post Office indicated no large systematic difference in length of service.
4. The cost estimate formulas were revised upward to include a higher installation cost. Also the cost of installation of polyurethane media is not included in the initial cost of the rolls as previously indicated.

5. Some general observations and conclusions based on the combined results of this report and NBS Report 10025 are:

   A. On the basis of service records it probably would be justifiable to use polyurethane foam along with glass fiber at the Philadelphia Main Post Office and obtain concurrent service records comparable with records already available for fiber glass.

   B. If polyurethane foam is considered for general procurement for all post offices, it would be desirable, if possible, to resolve such questions as whether the superior length of service of polyurethane foam is due to intrinsic superiority of the media or due to unidentified factors in the operation of a roll filter apparatus. Also, why are service records of filter media so variable, and why should a media which has a lower dust holding capacity in laboratory tests outlast a media with higher dust holding capacity?

Evaluation of Air Filter Media

by

Charles M. Hunt

Supplement to NBS Report No. 10025

1. Introduction

The technical objective of this project is to evaluate the dust arrestance and usage of open-cell polyurethane foam and fiber glass roll media when used as prefilters in air conditioning units in the Philadelphia Main Post Office. The purpose is to obtain comparative performance and media consumption data for foam media and for fiber glass media now used by the Post Office, with a view to decreasing the annual cost of prefilters, and obtaining equal or better filtering performance.

In NBS Report 10025 to the Post Office some estimates of the comparative cost of using polyurethane foam and fiber glass media at the Main Philadelphia Post Office were made. These estimates were based projected length of service made after 5-months of observation. It is the purpose of the present report to update this information and make any necessary modifications based on later information and on 11-months observation of filter usage. Some laboratory and field data on washed polyurethane foam media are also presented.

2. Revision of Cost Estimate Formulas

The cost of media for the air handling units in the Philadelphia Main Post Office is summarized in Table 1. This is a modification of Table 13 in NBS Report 10025. In the earlier report the cost of installation was included in the cost of the roll. However, this installation cost is not included in the cost of the roll as previously indicated. Therefore Table 1 is simply a breakdown of the cost of the media itself. The cost per roll of media upon which the table is based is $26.20, $32.00, and $34.50 respectively for nominal 3 ft., 4 ft., and 5 ft. rolls of polyurethane. The comparable costs of fiber glass rolls are $18.75, $24.90, and $29.10. This cost information and its source is given in Table 14 of NBS Report 10025.

From the total cost of filters required to fill all of the units, the annual cost of media per year, exclusive of installation cost, may be estimated from the formulas,

$$\text{annual cost of polyurethane (media only)} = 1992 \times \frac{365}{\text{average days of filter service}} \qquad (1)$$

$$\text{annual cost of fiber glass (media only)} = 1546 \times \frac{365}{\text{average days of filter service}} \qquad (2)$$

Equations 1 and 2 are presented graphically in Figure 1. They are presented in this way to illustrate the large increase in cost as the length of service decreases and to provide a rapid visual method of converting average length of service into comparative cost. For example, if the average length of service summed over all of the units is 170 days, inspection of the graph shows that the cost of fiber glass media would be about $3300 and polyurethane about $4300. Moving horizontally on the graph, it may be seen that polyurethane would have to last about 220 days to break even in media cost with fiber glass which lasted 170 days. The horizontal lines in the graph are 20 percent marks. Each line represents 20 percent lower cost than the one above it. Thus if fiber glass lasts 170 days, polyurethane would have to last about 270-275 days to afford a 20 percent saving in media cost. The purpose of presenting this analysis at this point is to have available a rapid visual means of estimating cost as the estimates of average length of service of filters are developed in the subsequent sections of this report. The cost formulas and figures are based on all of the air handling units but may also be applied to a smaller or larger number of filters where comparative rather than absolute costs are sufficient.

In NBS Report 10025 the cost of installing filters was based on the assumption that approximately 1/2 man-hour was required to change a single filter. This estimate did not include travel to and from the filter unit. Actually Unifilter charges $5 per roll to change filters irrespective of size. Maintenance personnel at the

Philadelphia Post Office estimated that about 4 man-hours were required to change a 3 filter unit. At current pay scales this also corresponds to an installation cost of about $5 per roll. Since 63 individual rolls are included in this estimate,

$$\$5 \times 63 = \$315$$

is the estimated cost of a single installation of filters in all of the units. Thus equations 1 and 2 are modified to obtain the following cost estimates for installed filter media,

$$\text{annual cost of polyurethane (installed)} = 2307 \times \frac{365}{\text{average days of filter service}} \qquad (1a)$$

$$\text{annual cost of fiber glass (installed)} = 1861 \times \frac{365}{\text{average days of filter service}} \qquad (2a)$$

Equations 1a and 2a are presented graphically in Figure 2. From this figure it may be seen that if fiber glass had an average length of service of 170 days, polyurethane would have to last about 265 days on the average to offer a 20 percent saving.

3. Estimates of Length of Service and Cost of Media

A. First set of filters

In Table 2 the length of service of polyurethane foam and fiber glass are compared, considering only the first installation each year. This is a modification of Table 7 in NBS Report 10025, updating it to include 331 day observations of polyurethane usage. During this period, filter changes had been made in 15 out of 19 units, while after 149 days, when the first estimates were prepared, only one set of filters had been changed. The 331 day estimate of length of service averaged over the 19 units was 297 days. This is slightly higher than the original estimate of 280 days for the same units, but both of these values are higher than the average length of service for fiber glass which was 173 days. This latter value for fiber glass is higher than the estimate of 165 days given in Table 7 of NBS Report 10025, because data for units 2A, 2B, and 2C have been removed from the table.

The foregoing estimates of length of service may be inserted in equations 1, 1a, 2, 2a, or in Figures 1 and 2 to obtain comparative cost estimates of polyurethane and fiber glass. As previously mentioned the cost formulas are based on all of the units while in Table 2 length of service is based on 19 units. The five omitted units are on the lower floors where length of service tends to be shorter. If comparable usage data were available for all 24 units, the averages for both polyurethane and fiber glass would be expected to be a little lower and the estimated costs a little higher than those developed from the formulas. Nevertheless applying Figure 2 to the averages developed in Table 2, it is estimated that 173 days length of service for fiber glass would correspond to about $3900 per year for installed media. Polyurethane foam would have to last about 270 days to offer a 20 percent saving. Thus both of the estimates of average length of service of polyurethane based on the first set of filters would correspond to cost savings of more than 20 percent over fiber glass.

B. Subsequent sets of filters

In seven of the air handling units a second set of filters completed its service period or had been installed long enough to permit a valid estimation of length of service, and in one unit estimated length of service was obtained for a third set of filters. This information, along with data for the initial set of filters, is summarized in Table 3. In 7 out of 8 comparisons the subsequent sets of filters did not last as long as the first set. These figures were all obtained

from units on the lower floors, and the averages are therefore smaller than those in Table 2. The average length of service of the original filters in these seven units was 202 days, while the average for subsequently installed filters was 125 days. These values are compared with 112-113 days for fiber glass.

Estimates of absolute costs read from Figure 1 or 2 would be too high for both polyurethane and fiber glass, because usage data are based on seven units located on the lower floors. However since the figures are proportionally correct for a smaller number of filters, it may be seen from Figure 2 that 113 days of average filter service for fiber glass would correspond in cost with about 139 days for polyurethane. Or polyurethane would have to last about 175 days in these air handling units to afford a 20 percent saving. The average of 125 days for the 2nd and 3rd set of polyurethane filters would correspond to a cost slightly higher than fiber glass, but the overall average of 166 days would correspond to a saving of about 15 percent. Thus, while the average cost of polyurethane would be less than that of fiber glass, usage data for both media is variable in nature, and it is possible to select instances where polyurethane costs more than fiber glass.

C. Seasonal effect on filter usage

It has been suggested that one of the reasons why subsequent installations of filter media did not last as long as the original filters is that there may have been a seasonal effect. If there are systematic differences in airborne dust levels at different times of the year, filters operating during periods of low dust concentration would be expected to last longer than filters operating when dust concentrations are high. Some evidence was presented for example in NBS Report 10025 that dust concentrations in the post office were higher when measured in August than in October, November or December. It was suggested that it might have been due to the relative amount of return air and fresh air passing through the air handling units. With this in mind, the 1963-1968 usage records from Table 4 of NBS Report 10025 have been reexamined. In Figure 3 the average length of service of fiber glass media in all of the units except 4C and 4D is presented according to months in which the rolls were installed. Monthly differences may be seen in the graph, but there is no evidence of any systematic seasonal differences. If it is assumed for purposes of discussion that the monthly differences in Figure 3 are systematic and repeatable rather than random, and if proportional adjustments are made in polyurethane usage data in Table 3, insufficient improvement in the length of service is obtained to alter the conclusions given in the foregoing section.

D. Run-off switch correction

In NBS Report 10025 (page 13), it was arbitrarily postulated that there was an average 5-ft. loss of fiber glass media per roll, because the run-off switch would signal end of roll when there was still about 5 ft. of media on the roll. The run-off switches were not used with polyurethane. However, according to conversations with plant maintenance personnel at the Philadelphia Post Office, the filters are not changed when the run-off switches signal end of roll. This is merely a warning, and the rolls are changed when, in the judgement of maintenance personnel, the rolls are finished. This is essentially the same criterion used for changing polyurethane rolls. Therefore the factor of 5 ft. per roll has been eliminated from cost estimates for fiber glass developed in the present report.

4. Washed Polyurethane Media

Polyurethane foam is a washable media. It is proposed to wash it and reuse it in service. Measurements were made in the laboratory to determine whether media which had been taken from service and washed had different air flow resistance than new media. Figure 4 shows the pressure drop of new and washed media at a series of air velocities. These data were obtained with 18 in. x 18 in. panels. The new media was part of a sample originally furnished for laboratory tests while the washed media came from air handling unit 2B. The results in Figure 4 suggest that rewashed media may have a slightly higher resistance to air flow than new media. However, more data on roll-to-

roll variability of the media itself is needed before it can be established with certainty that the differences shown in Figure 4 are are significant.

The amount of adhesive in polyurethane media also made a significant difference in its air flow resistance. This is shown in Figure 5 where pressure drop vs. velocity data are plotted for media which contains different amounts of adhesive. This may be important, because the concentration of adhesive per unit volume may be 6 to 8 times as high in polyurethane as in fiber glass. This is partly due to the fact that polyurethane is only about 1/4 as thick as fiber glass and partly due to the fact that the actual amounts per unit area in polyurethane were usually found to be larger.

In addition to the laboratory tests, 20 ft. rolls of washed media were run in unit 2B. The purpose of the short rolls was to obtain more cycles of use than would be possible with standard 65 ft. rolls. The length of service of new and washed media are shown in Table 4. There is no evidence of any large systematic difference between new and washed media.

5. Acknowledgement

The author is indebted to the late Mr. Lewis A. Tomes for air resistance measurements of new and used filter media shown in Figures 4 and 5 of this report.

Table 1

Comparative Cost of Placing Polyurethane or Fiber Glass in Each of the Air Handling Units at the Main Philadelphia Post Office

	No. & Size Filters			Cost of Media	
	3 ft.	4 ft.	5 ft.	Polyurethane	Fiber Glass
1A		3		$96.00	$74.70
1B		3		96.00	74.70
2A		3		96.00	74.70
2B		3		96.00	74.70
2C		3		96.00	74.70
2D		3		96.00	74.70
3A		3		96.00	74.70
3B		3		96.00	74.70
3C		3		96.00	74.70
3D		3		96.00	74.70
4A		1	1	66.50	54.00
4B		3		96.00	74.70
4C		3[1]		96.00[1]	74.70[1]
4D		3[1]		96.00[1]	74.70[1]
WP-1		3		96.00	74.70
EP-1		1		32.00	24.90
EP-2	1	1		58.20	43.65
EP-3		3		96.00	74.70
EP-4	1	1		58.20	43.65
EP-5	1	1		58.20	43.65
EP-6	1	1		58.20	43.65
EP-7		3		96.00	74.70
EP-8	1	1		58.20	43.65
EP-9		1	1	66.50	54.00
Total	5	56	2	1992.00	1546.35

Table 2

Comparison of Length of Service of Fiber Glass and Polyurethane, Considering the First Installation in Each Year

	Polyurethane		Fiber Glass
	after 149 days observation	after 331 days observation	
1A	204	187	177
1B	207	201	92
2D	63	63	149
3A	232	201	129
3B	255	273	114
3C	149	132	91
3D	204	210	102
4A	205	258	126
4B	200	224	134
WP-1	410	431	256
EP-1	319	331	200
EP-2	307	331	282
EP-3	359	307	200
EP-4	532	538	251
EP-5	168	152	193
EP-6	348	408	250
EP-7	538	650	225
EP-8	296	338	211
EP-9	331	404	169
Average	280	297	173

Table 3

Length of Service of Polyurethane and Fiber Glass Media Including Original Installation and Subsequent Sets of Filters

	Polyurethane				Fiber Glass	
	Original filters	2nd set	3rd set	Average	Average 1st installation each year	Average 1963-68 data
1A	187	64		126	117	128
1B	201	140*		171	92	105
3A	201	154*		178	129	123
3C	132	111	177*	140	91	98
3D	210	119		176	102	99
4A	258	127*		203	126	112
4B	224	108*		166	134	120
Avg.	202		125	166	113	112

* Estimated

Table 4

Comparison of Length of Service of New and Washed Polyurethane Foam Media*

	Length of service (days)
New	31
	31
Washed	57
	22
	27
	26**

* 20 ft. rolls

** Estimated

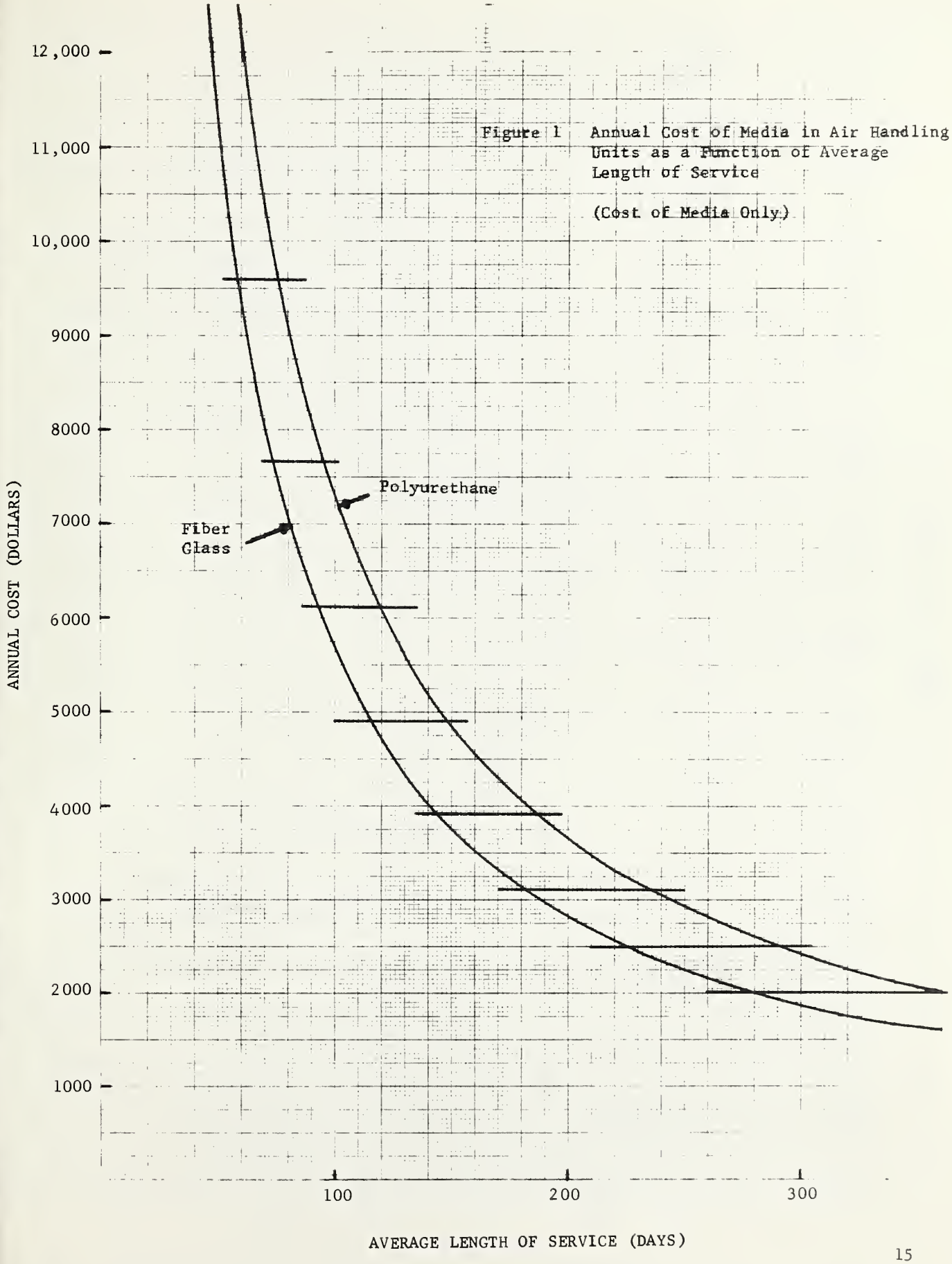


Figure 1 Annual Cost of Media in Air Handling Units as a Function of Average Length of Service

(Cost of Media Only)

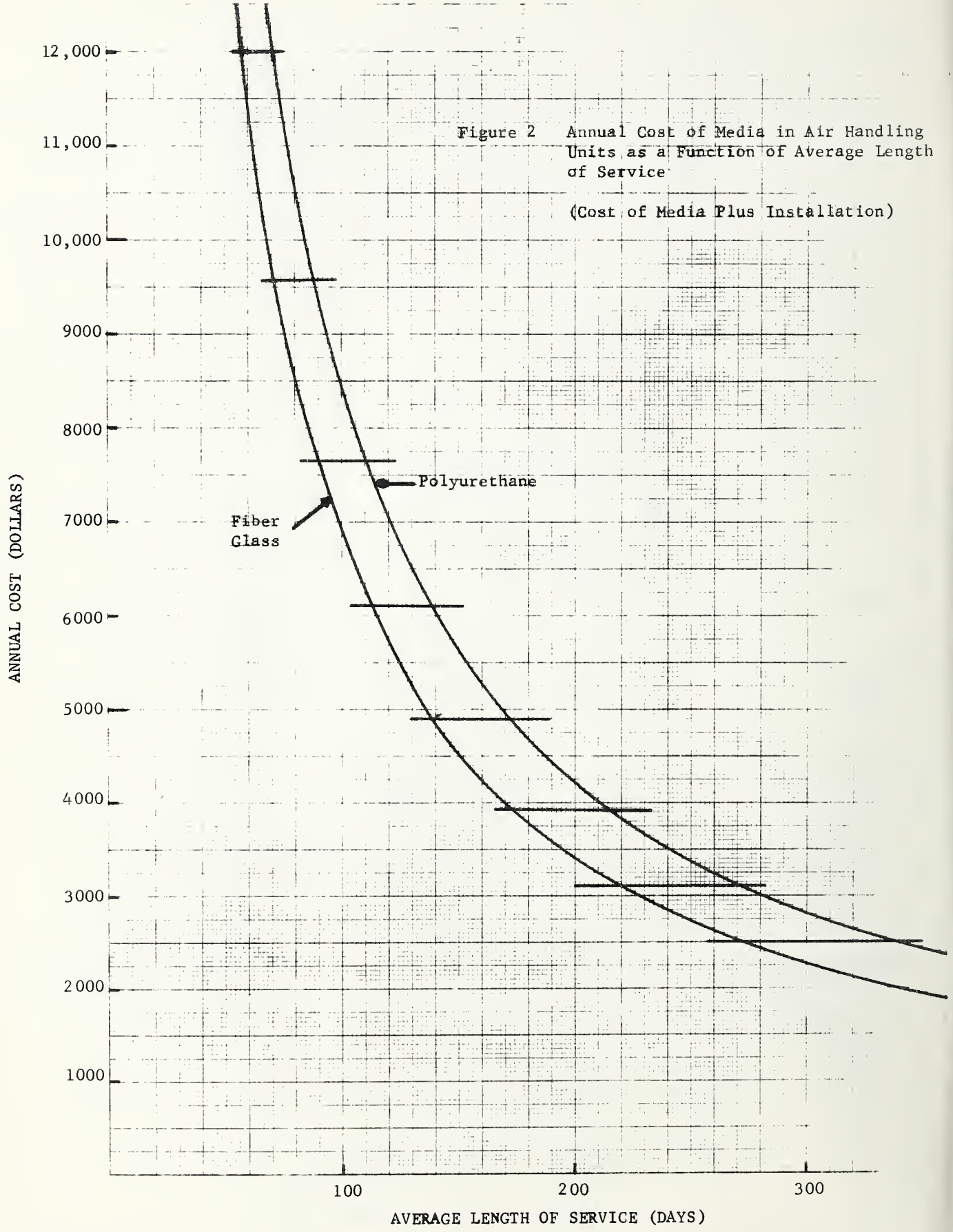
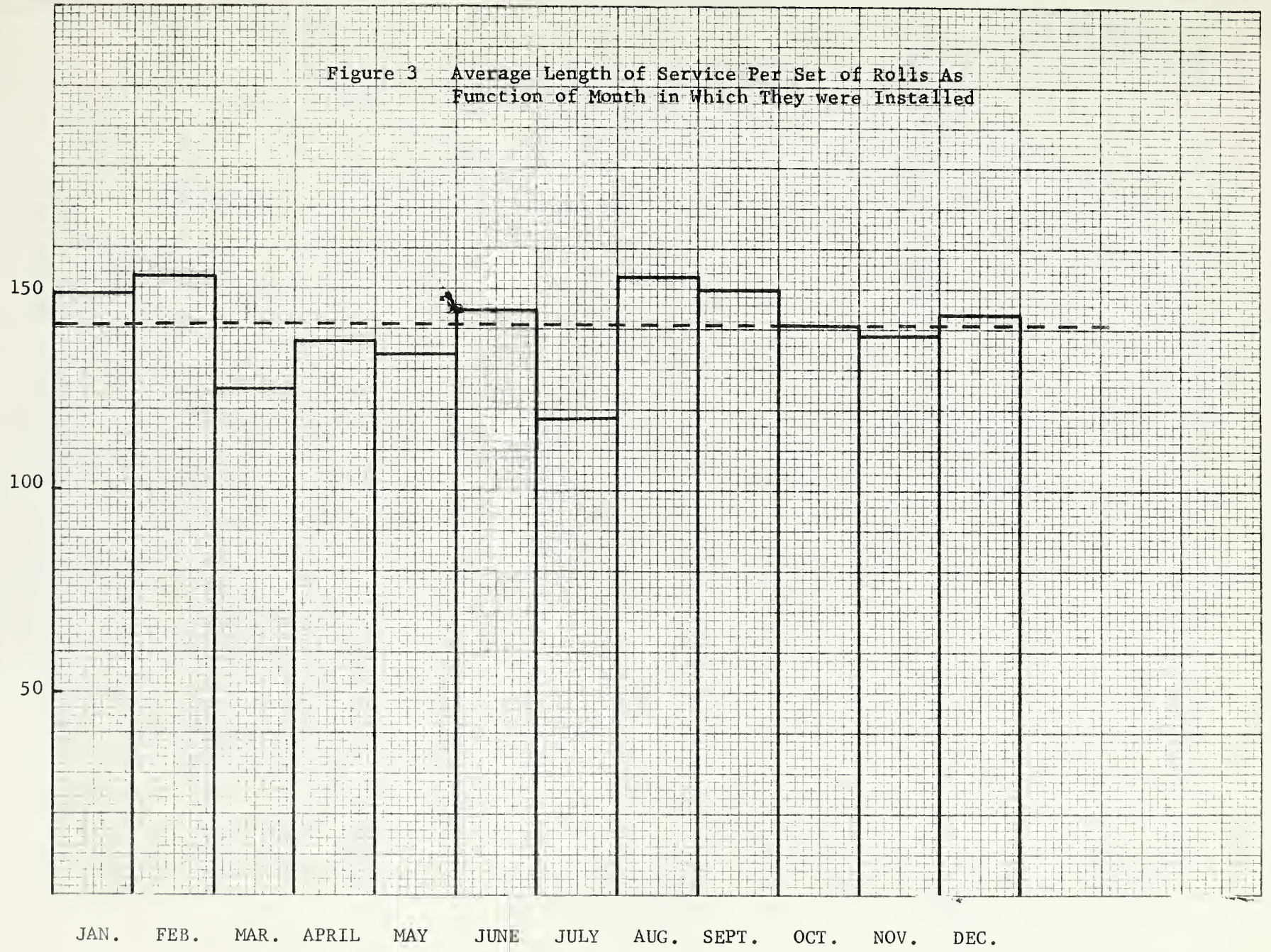


Figure 2 Annual Cost of Media in Air Handling Units as a Function of Average Length of Service

(Cost of Media Plus Installation)

Figure 3 Average Length of Service Per Set of Rolls As Function of Month in Which They were Installed



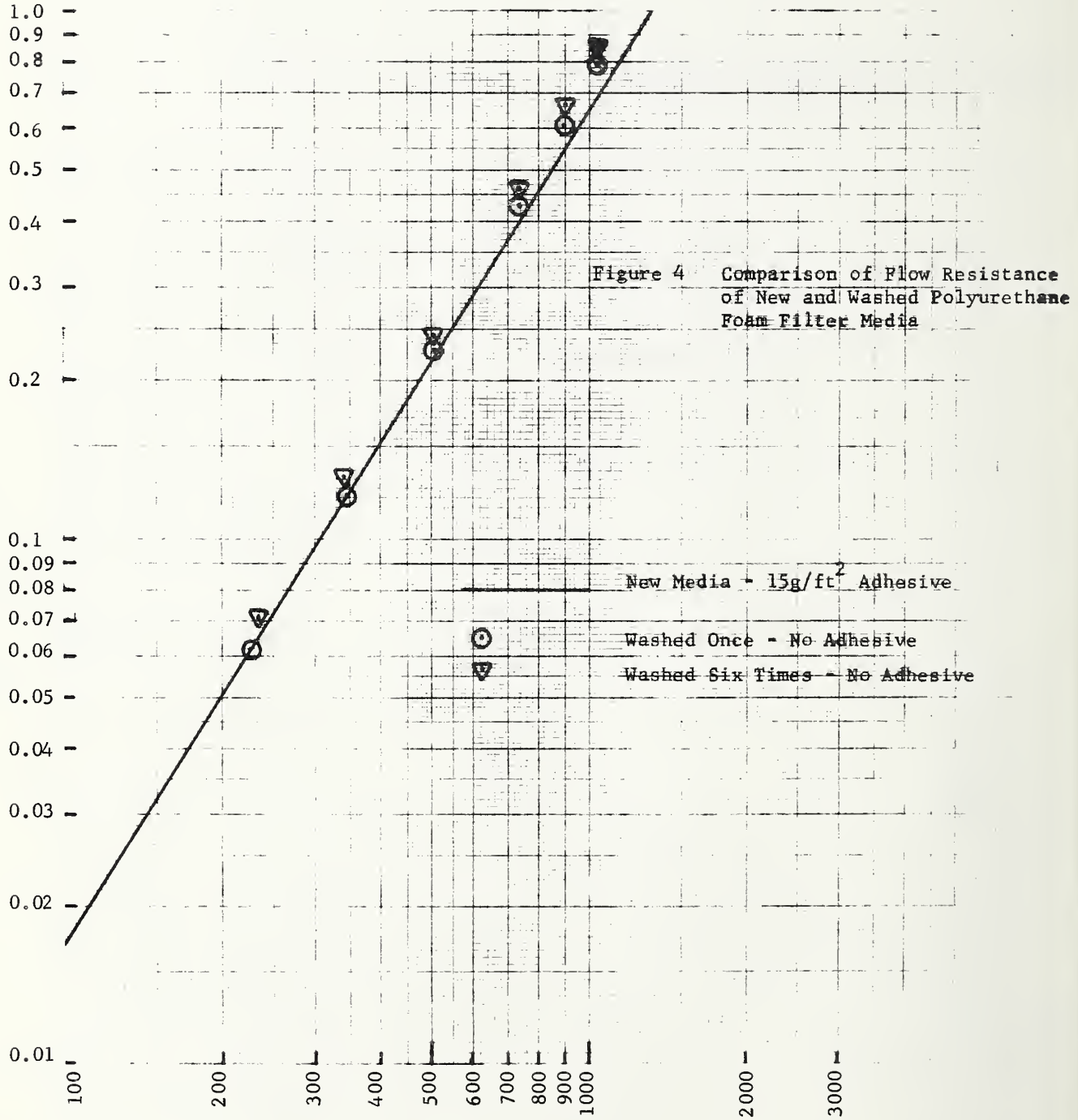


Figure 4 Comparison of Flow Resistance of New and Washed Polyurethane Foam Filter Media

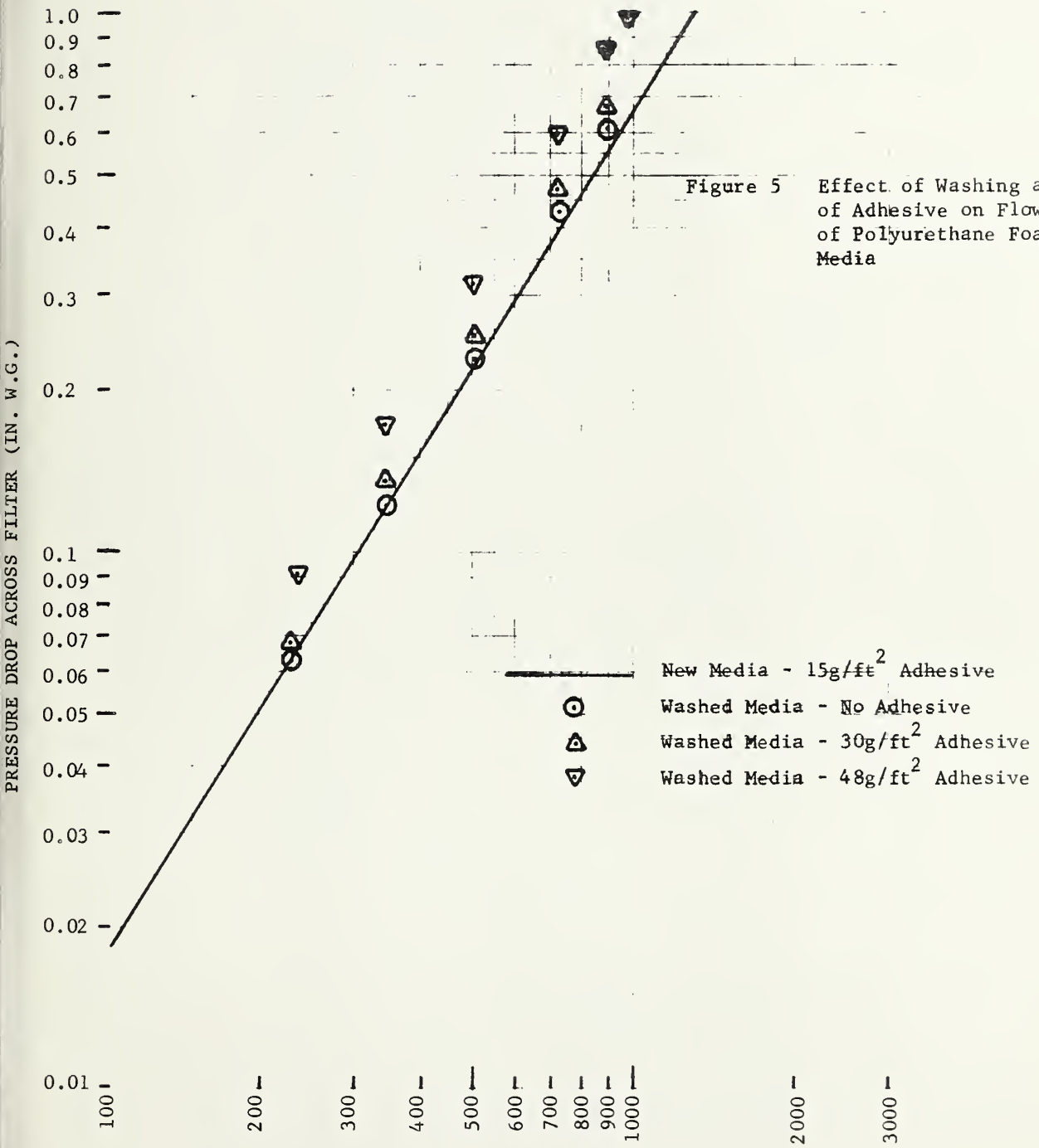


Figure 5 Effect of Washing and Addition of Adhesive on Flow Resistance of Polyurethane Foam Filter Media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